Mankind is preparing to take a step towards other planets. Several countries pursue plans for establishing permanent inhabited bases on Moon and Mars. These bases will have to develop eventually the self-sustained production of all the necessary products, including mineral resources. In contrast to Earth, which continues to evolve, other planets got nearly "frozen" at those stages of evolution that Earth has passed 3-4 billion years ago. Due to this, investigation of the early stages of Earth evolution has a direct implication for the other rocky planets. It will allow us to better understand what kind of mineral resources can be found on other planets, in which planetary environment, etc. Deciphering the regularities of the early Earth evolution is also important for the understanding of the origin of life and its early survival on our planet. Hence, knowledge about the early stages of Earth evolution is needed to better understand the geological processes occurring on our planet, predict what kind of minerals resources (and where) can we expect on other planets, and make a progress in the understanding of the origin and evolution of life.

The investigation of the early evolution of Earth is very complicated due to several circumstances. First of all, the oldest rocks have experienced several episodes of metamorphic reworking, that have almost completely erased their primary features that can be used for the understanding of the early Earth. Moreover, most of the oldest rocks have been destroyed during the long history of Earth. The oldest material, available for the direct study is represented by mineral zircon, which due to its remarkable chemical and physical durability can preserve information about geological processes that acted on our planed during the first days of its existence. The oldest terrestrial zircon was found in Western Australia and dated at around 4.4 billion years. However, zircons older than 4.0 billion years are extremely rare. The rock record starts at ca. 3.9-3.8 billion years, and such rocks were found on all continents.

In the proposed project we plan to investigate zircons (and mineral inclusions in zircons) separated from the oldest rocks in the Ukrainian Shield (these are between 3.8 and 2.8 billion years old), Slave Craton in Canada (these are the oldest rocks in the world dated at ca. 4.0 billion years), and Yilgarn and Pilbara cratons in Australia. The main focus will be made on the poorly studied Archean rocks of the Ukrainian Shield. Australian samples are represented in our collection by zircon from the Jack Hills conglomerates (the famous occurrence of the zircons older than 4.0 billion years), Archean granitoids and the oldest known basic rocks (anorthosites) from the Narryer terrane (ca. 3.7 billion years old). In total, we plan to investigate around 50 samples.

During the project implementation, we will address the following research questions: (1) How did the first stable continental crust develop? (2) How fast did the process of formation of the stable continental crust proceed? (3) When did plate tectonics start? (4) What was the fundamental difference between the Hadean and Archean mafic crust that did not allow the Hadean crust to persist?

We plan to address these questions by achieving the following research goals:

1. Construction of the hafnium isotope composition map of the Ukrainian Shield, which will allow estimation of the volume of continental crust produced at different times. Using this map, we will be able to contribute to the understanding of the rates of continental crust formation.
2. We will also construct the εHf – age plot and compare it to already existing plots for other Archean domains worldwide. This plot will allow us to trace mantle evolution through time.
3. Detailed petrochronological study of a few key samples collected in the Ukrainian Shield and other areas of interest. The combination of various isotope methods will allow us to constrain the geological history of the studied rocks, including those relatively low-temperature events that are not revealed in the mineral composition of the rocks.
4. We will apply the recently developed methods of isotope-geochemical studies of mineral inclusions in zircon that allow obtaining reliable information regarding Sr isotope composition in apatite or Pb isotope composition in feldspar.
5. We plan also to investigate the usefulness of the emerging methods of isotope studies, namely Zr isotopes in zircon and Cl and O isotopes in apatite.
6. Finally, we aim at collecting a large volume of trace element data in zircon that can provide valuable data regarding the chemical composition of the melt from which these zircons have crystallized, the degree of melt fractionation oxidation state, etc.

We expect that the successful implementation of the proposed project will have a great impact on our knowledge regarding the evolution of early Earth. We plan to contribute to the understanding of the evolution of different isotope systems through time. By doing this, we will be able to provide additional information about the processes and rate of continental crust formation. We aim also at providing additional information regarding the time of the plate tectonics initiation. This information may be also used for the understanding of the evolution of other rocky planets and better prediction of mineral resources distribution. In a more distant sense, our results will contribute to a better understanding of the origin of life, formation of the hydrosphere, evolution of atmosphere composition etc.